Board 119: Exploring Factors and Support for Effective Faculty Mentoring of Undergraduate Students in Engineering

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Exploring Perceived Efficacy and Support of Faculty Mentors of Undergraduate Students in Engineering

Abstract

This full research paper explores the role of faculty mentors in supporting student mentees. Faculty mentors of undergraduate students have the ability to make an academic, professional, and/or personal impact on their students. For example, mentors may provide assistance with course planning, share career goal feedback, offer life advice, etc. The benefits of these relationships may prove to be especially valuable in competitive fields such as engineering.

While students stand to gain much in mentor/mentee relationships, these interactions can be mutually beneficial, producing positive effects for mentors. Despite the importance of faculty mentoring undergraduate students, there is a gap in understanding what enables faculty mentors to feel effective in their roles. The majority of studies focus on student-related outcomes and do not delve into the mentors' side of the relationship. Addressing this gap can serve to enhance the quality of student education by providing insight into mentoring relationships.

This paper will utilize Zachary's model for effective mentoring to understand the foundation of effective mentoring. This model provides a framework for understanding mentor-mentee interactions by describing the seven elements of an effective relationship: reciprocity, learning, relationship, partnership, collaboration, mutually defined goals, and development. Mentors in academia are put in the position to orchestrate student growth through these areas by lending their guidance and expertise.

In order to better understand the faculty mentor experience within one-on-one and small-group faculty-to-student mentoring relationships in the undergraduate setting, this qualitative project will study a cohort of engineering faculty mentors of undergraduate engineering students at a mid-sized research university in the Midwest. Two research questions will be examined:
   a. What are the factors that enable faculty mentors of undergraduate engineering students to feel effective in their role?
   b. How can engineering faculty be supported to enhance their mentoring interactions?

The primary focus of this study will be to fill a critical gap in the understanding of faculty mentoring of undergraduate students by investigating the factors that enable faculty mentors to feel effective and proposing strategies for their support.

Introduction

To fully understand the feelings and needs of faculty mentors, it is first critical to understand the roles they play in their students' lives. Faculty mentors are professors who voluntarily meet with and mentor students, usually sharing the same field of study. Faculty mentors of undergraduate students have the ability to make an impact through academic, professional, and/or personal guidance. For example, mentors may provide assistance with course planning, share career goal feedback, offer life advice, etc. Undergraduate students are learners in the university setting pursuing bachelor's degrees, traditionally in the age range of 18-22. Mentors can take on a variety of roles in their students' lives such as advisor, instructor, employer, or agent of socialization (Lechuga, 2011, p. 763).

While students stand to gain much in mentor/mentee relationships, these interactions can be mutually beneficial, as studies have found that mentors experience increases in sense of accomplishment, interest in academic work, and exposure to new ideas (Zellers et al., 2008, p. 558). Recognizing the benefits of mentorship, many universities implement mentoring initiatives in their undergraduate programs to promote increased overall retention in addition to individual student growth. Despite the importance of faculty mentoring undergraduate students, there is a gap in understanding what enables faculty mentors to feel effective in their roles. The majority of studies focus on student-related outcomes and do not delve into the mentors' side of the relationship. Addressing this gap can serve to enhance the quality of education by providing universities with data on how to bolster mentoring as a crucial pillar of the student support system (Vesilind, 2001, p. 409).

This paper will utilize Zachary's model for effective mentoring to understand the foundation of successful mentoring relationships. Zachary's model describes effective mentoring as combining the elements of "reciprocity, learning, relationship, partnership, collaboration, mutually defined goals, and development" (Zachary, 2011, p. 142). These factors will be explored throughout the duration of this project work.

In order to better understand the faculty mentor experience within one-on-one or small-group faculty-to-student mentoring relationships in the undergraduate setting, this qualitative project will study a cohort of engineering faculty mentors of undergraduate engineering students at a mid-sized research university in the Midwest. Engineering faculty and students will be defined as individuals working for or studying in the departments of Civil/Environmental Engineering, Electrical Engineering, Mechanical Engineering, and Computer Science as these are the disciplines covered by this university's mentoring program.

The research questions included in this qualitative study focus on faculty mentoring of undergraduate engineering students, specifically focusing on the faculty members' perspectives within these relationships. The first question will focus on the elements that influence faculty's mentoring experiences. The question will be framed as follows: *What are the factors that enable faculty mentors of undergraduate engineering students to feel effective in their role*? Potential factors could include previous mentorship relationships, experiences in other university or industry settings, interpersonal communication styles, etc.

The secondary question will be worded as follows: *How can engineering faculty be supported to enhance their mentoring interactions*? Interview data from the faculty perspective will be collected in an effort to grasp what resources are necessary to support positive mentoring experiences. This portion of the research will provide context for what actions need to be taken to establish or strengthen support systems for effective faculty mentoring.

This project will contribute to the field of engineering education by addressing faculty mentoring, a component of the undergraduate experience that can play an important role in a student's development and post-graduation trajectory. By identifying the determinants of effective mentoring, institutions can tailor their mentorship programs to cultivate increasingly supportive and productive environments, thus improving students' academic performance, professional development, and overall satisfaction. Exploring strategies to support engineering mentoring may produce results that extend beyond engineering and advance knowledge of mentoring in other fields as well. The results of this study could drive the development of institutional policies that empower faculty to better support students.

Literature Review
As a preliminary step in this qualitative project, a review of existing literature was conducted in an effort to address the research questions through the current knowledge base. The review centered on peer-reviewed journal articles from the last ten years (2012-2022) on the topic of one-on-one or small-group faculty mentoring of undergraduate students.

Faculty participants in mentorship programs typically consist of professors, research assistants, and other instructors in the university setting. The faculty are paired, either formally or informally, with a student mentee or mentees who will be under their guidance for an amount of time. A 2016 study conducted in Turkey found that mentoring may last beyond an assigned duration, with some relationships lasting for decades (Anafarta & Apaydin, p. 27). Mentors can be generally described as falling under the categories of "allies, ambassadors, and master teachers" but it is essential to note the fluidity and uniqueness of individual relationships (Lechuga, 2011, pp. 767-768). Washington and Mondisa (2021) assert that mentors have the potential to directly address key factors of student success such as academic integration, knowledge development, motivation, and monitoring (p. 905).

In formal settings, mentors and mentees are paired within a pool of program participants. The mentoring structure consists of regularly scheduled meetings in which the mentor can offer a mix of academic and professional support. This support can include course advisement, networking opportunities, and letters of reference. Such intervention has the potential to raise retention rates and increase students' likelihood of achieving personal and career goals (AuCoin & Wright, 2021, p. 608). In addition to influencing student retention, faculty also have the ability to sway student post-graduation pathways by inspiring the pursuit of STEM careers (Ceyhan et al., 2019, p. 255).

In contrast to formal mentorship, faculty-to-student relationships can occur on an entirely voluntary basis in informal settings. Informal mentoring relationships may be uniquely beneficial with more natural connections formed between mentors and mentees. Studies have found that "instructor-student relationships bear a striking resemblance to friendship in interpersonal

communication research" and initiating these interactions organically may lend to fostering bonds that are perceived to be more genuine in nature (Sidelinger & McManus, 2020, p. 31).

To examine the perspective of mentors in the undergraduate setting, this paper will utilize the seven tenets of Zachary's (2011) model for effective mentoring: "reciprocity, learning, relationship, partnership, collaboration, mutually defined goals, and development" (p. 142). These elements revolve around the concepts of "growth for the mentor and mentee, the focus on mentoring as a process of engagement for both parties, the reminder that mentoring takes preparation and dedication, and the belief that good mentoring focuses on the learners" (Mendiola, 2012, p. 491).

The element of reciprocity refers to the mutually beneficial nature of the mentoring paradigm. Learning relates to the promotion of knowledge between the two parties. The aspects of relationship, partnership, and collaboration describe the joint effort of the mentor and mentee to combine individual points of view into a shared experience. Lastly, mutually defined goals and development pertain to the predetermined trajectory of the relationship dynamic as well as the subsequent growth that can occur.

Mentoring yields innumerable benefits for both faculty members and students. Faculty mentors gain advantages such as increased research outputs and assistance in research work (Burns, 2020, pp. 46-47). Additionally, they receive direct feedback from students and establish informal bonds, fostering a collaborative and supportive environment (Sonawane et al., 2021, p. 9). From the student perspective, mentees experience a sense of belonging, productive goal setting, feelings of accomplishment, and emotional support (AuCoin & Wright, 2021, pp. 610-611).

Moreover, participants in one study reflected that faculty mentoring was "more helpful than other interventions" serving as a "crucial opportunity to learn about science, scientists, and scientific process…" (Ceyhan et al., 2019, p. 258). Chelberg and Bosman (2019) found faculty mentorship to be especially impactful to underrepresented STEM students as it aided in their "development, retention, persistence, and navigation of the postsecondary setting" (p. 45). Zeller's et al. (2008) research further emphasizes that mentoring results in higher satisfaction, improved professional skills, enhanced productivity, and increased student retention, largely due to the socialization factors of bonding, support, advice, and accessibility (pp. 570-571).

The information gathered in this literature review serves as a source of potential answers to the two research questions in this study. To enable faculty mentors of undergraduate students to feel effective in their role, several potential factors were identified. These factors include the quality of mentoring relationships, offering feedback mechanisms, and integrating intrinsic rewards into academic culture. Perceived efficacy of faculty mentoring interactions in engineering may be achieved by emphasizing these elements. Drawing from the data collected in previous studies, engineering faculty may be aided in their mentoring interactions through training programs, diversity initiatives, feedback mechanisms, and incentives. These measures may collectively lead to more rewarding mentoring experiences, benefiting both mentors and their mentees, and contributing to the overall success of mentorship programs in the university setting.

Methods & Instrument
The research method, including sampling procedures, participant information, data collection, and data analysis techniques, will be outlined in the following section. These tools were applied in order to answer the research questions of interest: What are the factors that enable faculty mentors of undergraduate engineering students to feel effective in their role? How can engineering faculty be supported to enhance their mentoring interactions?

The population of interest in this study is faculty who serve as mentors within engineering. Specifically, the participants sampled must be engineering faculty who have mentored undergraduate engineering students in a formal setting. The formal nature of the relationship is characterized by the fact that mentor/mentee pairs are assigned to each other within the confines of an undergraduate development program. The decision to include formal mentors was made so that all faculty had common ground in respect to their past mentoring experience.

To recruit study participants, purposive sampling, otherwise known as non-probability sampling, was implemented. This sampling method was appropriate since the university at which the data collection took place has one formal engineering mentorship program for undergraduate students, and professors involved in this initiative could be identified for recruitment. Prospective study participants were contacted via email. Four university faculty members who currently work in various engineering departments and mentor undergraduate engineering students were identified and agreed to participate in this study. Their demographic information is summarized in Table 1 below:

Participant Information		
ID	Title	Department
1	Associate Professor	Civil and Environmental Engineering
2	Associate Professor	Electrical Engineering Technology
3	Senior Lecturer	Electrical and Computer Engineering
4	Lecturer	Electrical and Computer Engineering

Table 1. Interviewee Demographic Data

Once participants were identified, data was collected using semi-structured interviews. Each participant completed one interview session that lasted for approximately 60 minutes. Each participant was asked to answer a series of open-ended questions with the option to prompt participants to expound upon various aspects of their answers. The questions that were used in the interview stage are listed in Figure 1 below:

1. Tell me about your experience mentoring undergraduate students.
2. Describe how your personal and professional experiences have influenced you in your role as a mentor.
3. How would you describe a relationship between a mentor and mentee?
4. How would you describe your role in the learning and development of your mentees?
5. How would you describe partnership and collaboration between mentor/mentee?
6. How would you describe the benefits of mentorship for you and for your mentee?
7. Describe your process of setting goals with your mentees.
8. How do you assess the effectiveness of your mentorship interactions?
9. What experiences have you had that made you feel effective as a mentor?
10. What mechanisms are in place in your department to support mentoring?
11. What mechanisms does YSU have to support mentoring?
12. What mechanisms should your department/YSU have to support mentoring?
13. Is there anything else you would like to share today related to what we have discussed?

Figure 1. Semi-Structured Interview Questions

Following the interviews, the qualitative data was analyzed using thematic analysis. The thematic analysis procedure began with the assignment of codes to each line of the interview transcripts. Next, these preliminary codes were grouped together according to their commonalities and compiled into a codebook. The codebook was then applied to the interview transcriptions. The most prevalent codes were grouped to generate subthemes, then the subthemes were grouped to derive themes from the data. Themes were derived with respect to the study's basis on Zachary's model for effective mentoring. Zachary's model is centered on adult learning and states that effective mentorship is comprised of 7 elements: "reciprocity, learning, relationship, partnership, collaboration, mutually defined goals, and development" (Zachary, 2011, p. 142).

Results

This qualitative research project aims to explore two pivotal research areas: the factors that enable faculty mentors to perceive themselves as effective in their mentoring roles and the potential support elements to facilitate improved mentorship practices at universities. These questions were viewed through the lens of Zachary's seven components of mentorship, with the data reflecting the elements of "reciprocity, learning, relationship, partnership, collaboration, mutually defined goals, and development" (Zachary, 2011, p. 142). Semi-structured interviews were conducted with four faculty members from diverse engineering disciplines, each lasting approximately one hour. Participants were selected via purposive sampling and were identified through their participation in a university mentorship program.

The findings suggest that a combination of personal attributes and institutional support is integral to faculty mentor effectiveness. Honest communication, subject matter expertise, and an altruist mentality emerge as key personal attributes, while peer networking programs, industry mentoring initiatives, advertising to attract more faculty participation, and collecting mentee feedback are crucial support mechanisms. Later discussion will delve deeper into these findings, exploring their implications for mentorship programs in undergraduate engineering education and proposing recommendations for institutions to better support faculty mentors.

The data analysis stage began with inductive coding which involved thorough familiarization with the qualitative data. This process consisted of transcribing recordings of the interviews and repeated readings of the transcripts to gain a comprehensive understanding of the content. During initial coding, codes were assigned to specific portions of the data to describe distinct elements of the information for later reference. This stage involved a line-by-line examination of the text, and since an inductive method was used, codes were generated organically from the data without predetermined categories.

Once the initial codes were generated, the codes were grouped into preliminary categories to identify connections between different codes. This step facilitated the development of a structured coding framework that evolved into the codebook. The codebook served as a tool for documenting the evolving set of codes, their definitions, and illustrative examples. Figure 2 below illustrates the codebook comprised of 14 codes that was developed for this project:

Figure 2. Mentorship Project Codebook

Code	Description	Example
Academic guidance	Mentors assist students with course projects, class schedules, and exploration of elective courses that align with student interests	"I tend to get a lot of questions when students are having trouble with classes outside or even inside our major, where they're like, 'I'm not doing well in this class and I think I should drop' or 'What should I do?'"
Emotional support	Mentors offered mentees encouragement and assistance with personal issues such as finances	"They're debating school versus job, and how can they cut down in time, or how can they get their school work done and still pay their bills and things so that. That's one where I've had a couple students, especially recently who, I don't know why they wanted to ask me about it, but I've definetly had that recently."
Enjoyment	Mentors expressed how mentoring reinforces love of teaching and their profession	"One of the things that I actually really enjoy about the whole aspect of teaching is it's a bit of that mentoring, assisting, helping... Part of what's needed here is helping young adults to prosper, an so I really like that aspect of it."
Evolving relationships	Mentors described developing deeper relationships with students as they progress from freshman to senior year	"Everybody when you first meet someone, you kind of have this default behavior you exhibit. And I think that's what happens early on in mentoring, and you continue to mentor throughout, and you learn people, you know them, and then it evolves."
Formal mentorship	Mentors described mentorship relationships in which they are assigned to mentees and meetings are regulated by a program or schedule; These relationships were characterized as rigid	"I'd say when I interactive in prescribed mentoring, assigned a mentor under the scholarship and other types of opportunities, students tend to view me just as a mentor for that specific thing."
Fulfillment	Mentors expressed how mentoring feels rewarding, makes work seem meaningful, and produces mutually beneficial outcomes	"Those are the days that aren't fun, but when you can see a former student and see that they're doing well and they have a good job or whatever, whatever nice thing that is happening out there, that's kind of what makes it feel worth doing all that mundane grading and all that stuff."
Informal mentorship	Mentors formed mentorship relationships through casual interactions that were not officially regulated by a program; These relationships were described as natural and resemble peer-to-peer interactions	"The bulk of it has been kind of just through natural interaction. I've mentored students that have come to me for advice... 70%, it's kind of like informal. They'll see me in the hall or they swing by my office hours... it feels like it's more spontaneous and natural."
Long term effects	Mentors work toward goal of student success post graduation and often hear positive feedback from graduates	"I like to to hear from my students that they achieved their dream."
Ongoing relationships	Mentors maintained relationships with students throughout their four years in college with some relationships lasting beyond graduation	"That I think is closing the loop. They're not just receiving, they come back and share."
Personal mentor experience	Mentors received past mentorship from academic or professional sources	"Having a mentor, I was able to talk through some of the things that were just bouncing around in my head. Someone who had a little bit more experience than me, that was open and communicative and who didn't belittle me when I had some questions that might not have seemed that big of a deal to them."
Priority	Mentors value participating in mentorship and make time for it in their schedules	"I do really value it, and I think it's something to experience for students. So unless I am utterly overwhelmbed, which does happen from time to time, I won't turn the student away if they need a little bit of help. I really try to squeeze them in."
Professional development	Mentors provide help with internships, career planning, interviews, and letters of recommendation	"I would describe the relationship as a person who can provide valuable informed decisions, or help with informing decisions about career, and provide critical feedback regarding performance, and also letters of recommendation when needed."
Student engagement	Mentors assess the effectiveness of their mentorship by correlating higher levels of student engagement with success	"I don't measure it with numbers. I measure it is a successful interaction if I see the student eager to come to see me and eager to come and tell me how they're doing in classes and ask more questions."
Supplemental support	Mentors expressed need for additional resources such as peer mentoring, advertising to faculty, mentee feedback, etc.	"At the time, the was years ago, um, it was not the most effective. I really needed some outside help."

After the codebook was created, the categorized codes were applied to the entire interview data set in a second round of coding so that the relative prevalence of the codes could be observed. The relative frequencies of the applied codes can be seen in Table 2:

Code	Count	Relative Frequency
Academic guidance	38	16%
Professional development	28	12%
Informal mentorship	28	12%
Emotional support	22	9%
Evolving relationships	20	9%
Long term effects	16	7%
Fulfillment	15	6%
Supplemental support	13	6%
Formal mentorship	12	5%
Personal mentor experince	12	5%
Student engagement	12	5%
Enjoyment	7	3%
Ongoing relationships	7	3%
Priority	4	2%
Total	234	100%

Table 2. Relative Code Frequency Table

The eight most significant codes were identified to be: academic guidance, professional development, informal mentorship, emotional support, evolving relationships, long-term effects, fulfillment, and supplemental support. These codes were subsequently grouped into four subthemes: genuine personal connections, holistic impact, student advancement, and potential for improvement. Lastly, the subthemes were combined to create two overarching themes. The first theme is: mentors form emotional connections with their mentees starting in freshman year that evolve through senior year with the potential to endure past graduation; mutually beneficial effects can impact mentorship participants both during active participation as well as in the long run. The second theme is: mentors provide students with expert guidance both in the realm of academia and in the professional world; mentors identified deficiencies that if addressed could provide additional benefits to their student mentees. These themes will undergo a more detailed analysis in the forthcoming discussion section.

Discussion
This study identifies key personal attributes that influence faculty mentors' perceived effectiveness. Honest communication, subject matter expertise, and an altruistic mentality emerged as pivotal factors. Faculty mentors emphasized the importance of transparent communication to establish trust and genuine rapport with their mentees. Previous industry experience and subject matter expertise were elements that helped mentors provide valuable academic and professional guidance. An altruistic mentality, where mentors were invested in the success and well-being of their mentees, seemed to play a central role in fostering meaningful relationships that produced long-lasting effects for mentors and mentees alike.

Institutional support was investigated as a possible component that could enhance faculty mentors' perceived effectiveness. Faculty mentors noted a lack of formal mentorship initiatives, but all described a widespread desire amongst engineering professors to offer informal mentoring whenever possible. A suggestion to improve faculty support was the implementation of peer networking programs to facilitate collaboration and knowledge exchange among students. Other discussed additions included targeted advertising to attract more faculty participation to spread the workload of mentee support, additional mentoring by engineers in industry, and the systematic collection of mentee feedback to assess the benefit of current interactions. According

to the faculty's perspective, these institutional initiatives could contribute to mentors' perceived effectiveness and also enhance student success in mentorship programs.

The findings align with Zachary's model for effective mentoring, which emphasizes the elements of "reciprocity, learning, relationship, partnership, collaboration, mutually defined goals, and development" (2011, p.142). The personal attributes identified, such as honest communication and an altruistic mentality, resonate with the principles of building strong relationships and mutual learning. The suggested institutional support mechanisms align with the collaborative and partnership aspects of the model, emphasizing the importance of a supportive institutional framework. Effective communication establishes trust, subject matter expertise contributes to the mentor's perceived utility to their students, and an altruistic mentality reflects a genuine commitment to the success of mentees. These qualities, identified through the interviews, underscore the interpersonal dynamics crucial for effective mentoring.

Limitations
While an effort was made to select a robust theoretical framework, certain limitations in the depth and breadth of Zarchary's mentoring model may have influenced the interpretation of findings. Additionally, there were participant-related challenges, including difficulties in scheduling meetings with available professors which led to a limited sample size. Most significantly, the time constraint presented by the project timeline restricted the number of participants who could be scheduled.

Future Research
Future research in faculty mentorship should explore longitudinal studies to understand the evolution of mentorship relationships over time and compare outcomes across different engineering disciplines. Additionally, examining the efficacy of mentor training programs supplemented by other support mechanisms, such as peer mentoring, could prove useful in improving student outcomes. Recommendations for future researchers include assessing the impact of promoting cross-disciplinary collaboration or examining the ongoing mentor/mentee collaboration following graduation.

Conclusion
This research project has explored the role of faculty mentors in supporting undergraduate engineering students and the measures that might be taken to improve this support. The importance of faculty mentors in guiding students is beneficial to students and faculty alike. The study aimed to help fill a critical gap in understanding what enables faculty mentors to feel effective in their roles, a facet often overlooked in the existing literature that predominantly focuses on student outcomes. It also explored avenues for offering support to faculty mentors. Zachary's model for effective mentoring, which highlights the elements of reciprocity, learning, relationship, partnership, collaboration, mutually defined goals, and development, was utilized to frame interview questions and categorize their responses (2011, p.142).

The literature review conducted at the outset of the project provided a foundation for understanding the existing landscape of faculty mentoring in engineering. The qualitative data collected through interviews was inductively coded to identify themes. This process revealed that mentors form genuine emotional connections that evolve as their students progress through their

college journeys. These connections often lead to lasting relationships that can endure past graduation. Another finding was mentors guide students personally, academically, and professionally.

As a result, this research project serves to bridge a critical gap in the literature by emphasizing the perspectives of faculty mentors, ultimately contributing to a more holistic understanding of effective mentoring in the context of undergraduate engineering education. The proposed strategies for supplemental support could enhance the quality of mentorship programs, positively impacting student success and overall academic experiences. Through this endeavor, the study aspires to empower faculty mentors, strengthen mentoring relationships, and foster a more supportive and enriching learning environment for undergraduate engineering students.

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